Construction Innovation Report
Hydro-Demolition

B-4858 Deck Rehabilitation

Location: Bridge over Roanoke, Middle and Cashie River on NC 45

Division: 1 **County:** Bertie

Type of Work: Deck Rehabilitation

Type of Contract: Lump Sum with A+B

Scheduled Completion Date: August 15, 2005

Contractor: Cleco Corporation
Hydro-demolition Subcontractor: HydroTech

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Alternative Contracts, Constructability Engineer

INNOVATION REPORT

PROJECT #: 36828.1.1 **COUNTY:** Bertie **DIVISION:** 1

FEDERAL AID #: BRSTP-45(3), Bertie County

DESCRIPTION: This project consists of repairing the existing bridge deck by removing existing asphalt patches and loose, deteriorated or contaminated concrete and resurfacing with latex modified concrete overlay and pavement markings.

BACKGROUND

Bridge Number 7 in Bertie County was built in 1968. The bridge, which is approximately 1.1 miles long, has a reinforced concrete floor on prestressed concrete girders and continuous plate girders. Spalling of the concrete deck had resulted in spans being anywhere from 10% to 80% patched. These spans required constant maintenance. Bridge maintenance reports from 2004 projected the bridge to have an additional 18 years of service, but cited the need to repair the deck and perform some maintenance on the piers, abutments and caps. Instead of continual maintenance, a deck rehabilitation project was considered. Bridge Maintenance estimated that deck rehabilitation would extend the life of the bridge an additional 15-20 years, thus increasing the life of the bridge to 35 to 40 years. The size of the bridge, the length of an off-site detour (50 miles) and the close proximity of a school required the project to be done on a very compressed schedule. It was decided that the work would need to be done over the summer months while school was out of session and would need to be completed prior to the start of school. Milling and hydro-demolition had been used by NCDOT one time previously for a bridge rehabilitation project in Greene County and was proven to be a faster method of deck removal than the traditional method of a milling machine and lightweight jackhammers.

The Bridge Maintenance Unit prepared the quantities, provisions, plans, etc., with the help of Mulkey Engineers & Consultants. The project was advertised as a lump sum bid. In addition, a contract time, not to exceed 42 days, was to be factored into the bid. The project was let by the Project Services' Contract Office on May 17, 2005. The project was awarded to the low bid contractor, Cleco Corporation for the bid price of $2,921,100.00 with a contract time of 42 days. The daily cost of $1,500/day was added to the bid price for an adjusted contract price of $2,984,100.00. The project availability date was set at July 5, 2005 with a completion date of August 15, 2005.

PROJECT SPECIFICS

At the time of the field review on July 19th, the entire deck surface had been milled and hydro-demolition had been performed on approximately 30% of the deck. The screed was in place but no concrete overlay had been placed. The contractor had attempted to place concrete with Type III cement but had been unable to satisfy mix temperature requirements. The specifications require temperatures of the deck surface, ambient air, and concrete mix to be below 85°F before placement of the latex modified concrete. With average daytime temperatures approaching 100°F, these requirements made the operation difficult. The contractor decided to try placing concrete at night and to reduce mix temperature by using a higher content of Type I cement in lieu of Type III cement. Concrete was mixed on site using mobile mixers.

A series of sand filters are located between the first and second tanks in the water purification process.

Water containment was one of the main concerns with the hydro-demolition process. Before any work could begin, all deck drains were plugged and joints sealed in a manner that adequately contained all of the water. Water was drawn from the river, purified to a neutral pH of seven, pumped to the robot unit for use in hydro-demolition, recycled on site through the purification system and then re-pumped to the robot unit. The purification plant consisted of a settlement tank, a sand filter and an aeration tank. In the aeration tank, CO_2 is added to correct the pH level prior to reuse.

At the end of the process all treated water was carried to a site provided by NCDOT at the Division asphalt plant. A vacuum truck and a sweeper worked to clean up additional water and debris to be carried off site. The solid debris collected by the vacuum truck closely mimics the properties of crush and run gravel and can be sold by the contractor. On this project, the contractor placed the debris at the project staging area. The staging area was a parking lot for a local property owner's shop site and was considered a parking area improvement for the property owner.

The proposal identified four classes of surface treatment. Class A Surface Preparation included milling the concrete deck to a uniform depth of at least ½" but not into the top mat of steel. Class B Surface Preparation included hydro-demolition of unsound concrete to a uniform depth from the original surface (1- 7/8"). Class C Surface Preparation included additional removal of unsound concrete to approximately ½ the original deck thickness. Class D Surface Preparation included full depth removal and repair using Class AA concrete. Both Class C and Class D repairs also required cleaning and repair of reinforcing steel as required.

Plans included in the proposal gave approximate quantities for informational purposes. Estimates for Class C and D Surface Preparation were done by visual inspection based on the quantity of existing asphalt patching in the deck. In looking at other states' specifications for hydro-demolition, it appears that partial and full depth patching pay items measured by the square yard are being used more often than the lump sum payment used for this job. The advantage of traditional pay items would be to reduce the risk of incorrect quantities to the contractor. One disadvantage of traditional pay items includes an increased difficulty in administering the contract due to the fine line between different classes of surface treatments. In addition, the adjustment of the speed and pressure of the hydro-demolition equipment by the contractor can greatly affect the amount of concrete removed. While the goal is to remove only the defective concrete, additional partial and full depth repairs could be required based upon the settings of the hydro-demolition equipment. The overruns and time extensions associated with additional repairs could be beneficial or profitable to the contractor.

Bridge deck after hydro-demolition. NCDOT inspectors marked areas of unsound concrete for additional surface treatment.

One of the requirements of the proposal was that the mixer was not permitted on the bridge deck unless otherwise approved. The proposal also stated that no traffic is permitted on the finished latex modified concrete surface until the concrete reaches a minimum compressive strength of 3000 psi. These requirements, on a bridge of this length, are quite restrictive and would make the contractor's operations difficult and would require more time. The wording of this contract was taken from other states' provisions and was based upon the previous smaller hydro-demolition project in Greene County. The project in Greene County required new reinforcing steel to be placed in the existing mat therefore requiring the concrete to be removed completely from the steel. Traffic was not prohibited, so as traffic drove on the steel mat, the bars became displaced. The concrete on this project was not removed to the extent of the Greene County bridge project and displacement of rebar was not as big of a concern. Subsequently, it was decided to allow trucks on the bridge deck with cones used to block off areas to be avoided. This did not appear to be a problem and the Resident's office noted that they had more concern with the vacuum truck than the mixer trucks. Contract wording may need to be altered on future projects to better reflect actual field operations. Bid prices should more accurately reflect actual costs when NCDOT's field expectations are stated clearly within the contract.

The hydro-demolition work finished on July 28th. Temperatures continued to make placement of the concrete difficult, even while paving at night. The completion date of August 15th, which is associated with the start of school, was not met. However, the bridge was opened to traffic Friday, August 19th. The contractor continued working under lane closures, mostly at night to complete the grooving and joint work. The contractor was able to complete the work by September 7, 2005. Liquidated damages of $1,500/day were assessed. The damages amounted to over $25,000.

Being a lump sum contract, the Resident's office was not required to keep quantity records for this project. However, the Resident's office elected to measure quantities for Class C and Class D work in case of a claim issue. It appears the actual quantities for Class C appear higher than the estimated quantities, while the actual Class D Surface Preparation quantities appear to be lower than expected based on visual estimation.

COMMENTS

The comments included in this report include items noted from our site visit as well as conversations with staff of the Resident's Office and Mulkey Engineering & Consultants.

1. MATERIALS

- The contractor and the latex modified concrete supplier may join forces to lobby the Department against the 85°F maximum temperature requirement. Samples of the sand, stone and latex were taken from the job site for experimental purposes and sent to the manufacturer of the latex. It should be noted that 85°F maximum was shown in other states' specifications listed on the contractor's web site and this temperature seems to be within a range of temperatures accepted as industry standard.

2. PROPOSAL/CONTRACT

- The availability date for the project was July 5, 2005. While this was the earliest NCDOT was able to have the project let and made available, the effect of the summer heat would have been less had the project been made available in June. The impact of seasonal temperatures should be heavily considered on future projects and the let dates planned accordingly.
- The liquidated damages of $1,500/day may have been set too low for this project based on the perceived need to have this project completed before the start of school. It is not uncommon for contractors to build some liquidated damages into the cost of their bid when they anticipate needing more time to complete a project. The lack of contractors who could competitively bid on this job, could promote this practice, therefore eliminating the effectiveness of liquidated damages in limiting contract times stated in A+B bids.
- When discussing the Class B Surface Preparation using hydro-demolition reference is made to a uniform depth of 1-7/8" from the original deck surface. The deck dimension of 1-7/8" was the original depth of concrete cover as per the bridge construction plans from 1968. In actuality, this dimension varied greatly from the plans. A pacometer is a non-destructive method of obtaining the depth of the rebar, but may not be accurate. Prior to the milling on this project, a pacometer was used to measure the depth of steel. After the milling machine hit the steel several times over several days, the use of the pacometer was abandoned on this job. Destructive testing/coring may have been beneficial during the development of the contract.

3. RIGHT OF WAY AND UTILITIES

- Right of way and utility work was not required for this project.

4. CONSTRUCTION

- Extensive adjustments in the field were necessary to get a combination of speed and pressure appropriate to remove the unsound concrete without damaging or removing sound concrete, potentially exposing steel rebar. The more that the reinforcing steel is separated from the concrete, the higher the risk of displacement of the steel. In addition, by exposing the rebar during hydro-demolition, Class C (partial depth) repair may be warranted. Class C repair, which is partially defined by exposed rebar, involves additional removal to provide a ¾" minimum space below the bar. This space is necessary to allow aggregate in the concrete to be uniformly distributed when placed.
- There were some areas of minor steel displacement. A minimum 1½" concrete cover was required over the reinforcing steel. Where minimum cover was a concern, areas were checked with a probe and repairs were made as required.

5. ADMINISTRATION

- On projects where new technology is utilized, such as hydro-demolition, the Department often relies on specifications and information provided by contractors. While this information is helpful and necessary to the project, there is potential for conflicts of interest. In addition, if the Division is not included in the scoping process, there may be project details/information that the contractor has provided but that the Division is unaware of. This potentially puts the Resident in a difficult position.

6. EROSION CONTROL/PERMITS

- Required permits for this project include US Army Corp of Engineer's (USCOE) Dredge and Fill and/or Work in Navigable Waters (404) and Division of Environmental Management's (DENR) Water Quality (401) Certification.
- The Department provided monitoring of the in-stream pH and temperature both upstream and downstream of the bridge while the water-jet was in use. The testing was conducted at intervals determined by the Resident's office in conjunction with the Division of Water Quality. In addition, monitoring wells were required near the site the Department provided for the disposal of treated run-off. For this project, the Division utilized a waste pond at a nearby NCDOT asphalt plant site. Testing was performed on the wastewater and groundwater prior to release of the wastewater. Results from these tests were used to establish testing requirements for samples from the monitoring wells.
- The project was constructed within the permit constraints and all testing required has been performed to this point. There were no process failures that lead to noncompliance and the construction completed without incident. DWQ is requiring the monitoring wells to be sampled three times a year and tested for pH, sulfates, trace metals, etc. This requirement will continue until DWQ rescinds the permit.

7. SAFETY

- No specific comments were made regarding safety issues on this project. There did appear to be a potential for minor injury due to flying rock debris during the hydro-demolition process. Eye protection should be used during operation of the equipment as well as hard hats. In addition, hearing protection should be worn in the vicinity of the high-pressure pump unit.

8. WARRANTY

- This project required the standard twelve-month guarantee.

9. GENERAL

- Hydro-demolition is an effective method for rapid concrete bridge deck removal and should be considered for use on future bridge rehabilitation projects.
- The Bridge Maintenance Unit should be commended for their application of this technology to this project and other deck rehabilitation projects in the state. On April 27, 2005 the Bridge Maintenance Unit was presented with multiple awards for hydro-demolition at the NCDOT Continuous Process Improvement (CPI) Program. The awards presented included "Cycle Time Reduction Award" and "Most Outstanding Award". The "Cycle Time Reduction Award" recognized the most significant reduction in process cycle time of a core process within the Department. From the winners of the eight individual award catagories, the "Most Outstanding Award" was presented to the process improvement that exemplified the CPI Program and demonstrated the most effective use of a team.

RECOMMENDATIONS

- While Division Bridge Maintenance Engineers may oversee a majority of future hydro-demolition projects, there may be instances where a Resident would be involved instead. By allowing the Resident's office to assist in assessing the existing conditions, they will begin to get familiar with the project. In addition, more field information may be included in the scope of the project and duplication of testing may be reduced between the planning and construction stages.
- While a steel rod is the preferred method of sounding concrete, a production oriented, large-scale project might require the use of another method of sounding. More consideration should be given to the use of the Ground Penetrating Radar for testing concrete soundness. At least 6 DOT's in the country are using this technology with more then 10 others currently evaluating the use for deck evaluation according to the SHRP Product 2015: Ground-Penetrating Radar for Bridge Deck Evaluations by William Longstreet (available on request).
- Current specifications addressing the hydro-demolition equipment may give the impression that the 17,000 psi pressure is the controlling factor in removal of unsound concrete. The depth of concrete removal may be more influenced by the speed of the machine than the operating pressure. Specifications may need to be rewritten to better clarify the effects of speed and pressure in calibrating the depth of removal for project personnel unfamiliar with the process.
- On projects where completion time is this critical, liquidated damages should be greatly increased or consideration should be given to incentives/disincentives. By offering an incentive on a project similar to this, it gives the contractor the draw of additional profit and not just the threat of liquidated damages that may already be factored into the bid.
- As the use of Latex Modified Concrete becomes more prevalent, it may be necessary to give Resident Engineers more guidelines and instructions pertaining to the storage, handling and usage of LMC. For example, on this project if mixers were not allowed on the deck, would shuttle buggies or conveyors be allowed to transport mixed concrete?
- On projects where constructability input is required from the contractor or new technologies are being introduced to the Department, utilization of the Alternative Contracts Section is recommended. A formal external constructability review can be held to gather input from AGC recommended contractors, while keeping a professional separation between the Contractor and Department staff preparing the project specifications and overseeing the project.
- Future hydro-demolition projects of a large scale should be viewed as production based and the Department should continue to let these projects on a lump sum basis. The administration is simplified and quicker on lump sum projects. Traditional pay items may be considered for smaller deck rehabilitation projects utilizing hydro-demolition. Pay items would reduce the bidding risk and more accurately capture project costs.
- On future projects, wording in the specifications should be rewritten to allow mixers on the deck under certain conditions. An example of another state's provision reads; "Where reinforcing steel is exposed, the Contractor shall provide adequate supports for the concrete mixer so that reinforcing steel and its bond with the concrete will not be damaged by the weight and movement of the concrete mixer, or shall provide means to convey concrete from the mixer to the finishing machine."

Appendix

This contract used a lump sum dollar value to cover the milling, hydro-demolition and concrete overlay work. In addition, a mobilization line item and a $1,500/day contract time item were included. The project utilized an A+B contract. The bid information is as follows:

Engineer's Estimate: $3,347,297.03
Estimated Contract Time: 36 Days
NCDOT's Availability Date: July 5, 2005
NCDOT's Completion Date: Not more than 42 calendar days from availability, (August 15, 2005)

CONTRACTOR	ACTUAL CONTRACT AMOUNT	CONTRACT TIME	CONTRACT AWARD BASIS *	% DIFF
CLECO CORPORATION	$2,291,100.00	42 DAYS	$2,984,100.00	-10.9
LANFORD BROTHERS CO	$7,466,160.00	42 DAYS	$7,529,160.00	+124.9

* Contract Award Basis = Actual Contract Amount + Contract Time x $1,500/day

Based on the contract award amount, Cleco Corporation was selected to perform the work.

For this project it may be beneficial to provide a cost and time estimate for comparison had the work been performed by standard jackhammer and chisel method of removal. Bridge Maintenance offered the following:

Engineer's Estimate: $8,500,000.00
Estimated Contract Time: 360 Days